The Costs and Benefits of Pierce’s Disease Research in the California Winegrape Industry

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Benefit-cost analysis for R&D investments

• Research investments take a long time to take effect
  – R&D process
  – Technology development
  – Adoption process

• Then the consequences last for a long time
  – Typically decades, even for annual crops

• Long lags have important consequences for comparison of benefits and costs in present value terms

• The lags are likely to be even longer for perennial crops, especially for varietal technologies
Research benefits and costs

Gross annual benefits (dollars per year)

Year

R&D Lag

Adoption Process

Research Costs

Research Benefits
Approximate measure of benefits

• Individual vineyard or industry level gross annual research benefit (GARB)

\[ \text{GARB} \approx (y + p + c) \times a \times V \]

• \( y \) = proportional gain in yield per acre
• \( p \) = proportional price premium for product from new variety
• \( c \) = proportional saving in costs per acre
• \( a \) = proportion of total area planted to new variety
• \( V \) = gross value of production

\[ V = Y \times A \times P \text{ where } Y \text{ is yield per acre, } A \text{ is total area, and } P \text{ is price} \]
Approximate measure of benefits

GARB = (y + p + c) x a x V

• Does not
  – count costs of R&D, adoption, etc.
  – include nonmarket impacts
  – reflect induced changes in prices and resource use

• Is conditional on successful R&D leading to a useful technology

• Benefit-cost analysis takes these things into account as well as timing of adoption and thus of flows of benefits and costs
Conceptual model: Damage mitigation technology

• Market-level model
  – Used to show economy-wide impacts

• Based on vineyard-level model where
  – Pest or disease imposes damage, reflected in
    • lower yields
    • higher costs of production per acre or per ton
    • lower quality (price discount)
  – New technology mitigates damage for those growers who adopt it

• Market level model identifies distribution of benefits between producers and consumers (some of whom are foreign)
Supply and demand for wine grapes

![Graph showing supply (S₀) and demand (D) curves, with equilibrium at P₀ and Q₀.]

- Supply (S₀)
- Demand (D)
- Price (P₀)
- Quantity (Q₀)
Price and quantity effects of disease

![Graph showing price and quantity effects of disease](image)

- $P_0$, $P_1$, $Q_0$, $Q_1$, $S_0$, $S_1$, and $D$ represent various economic variables and relationships.

- The diagram illustrates how changes in disease affect market equilibrium, with price ($P$) and quantity ($Q$) as primary indicators.
Social costs of disease

The diagram illustrates the concept of social costs of disease. The graph shows the demand (D) and supply (S0 and S1) curves, with the social costs of disease represented by the shaded area between the supply curves and the demand curve. The increase in the price (P1) is also depicted, indicating a shift in the supply curve from S0 to S1, leading to a higher quantity (Q1) sold.
Distribution of social costs

Price

Consumer share of costs

P₁

Producer share of costs

Q₁

S₁

S₀

D

Quantity

0
Effects of mitigation

![Diagram showing the effects of mitigation on supply and demand. The diagram includes supply curves S0, S1, and S2, with price points P1 and P2, and quantity points Q1 and Q2.]
Benefits from mitigation

![Graph showing the benefits from mitigation with price P1, P2, and quantity Q1, Q2.]
Distribution of benefits from mitigation

Price

Consumer share of benefits

Producer share of benefits

D

S₀

S₁

S₂

P₁

P₂

Q₁

Q₂

Quantity

0
Distribution of benefits from mitigation

Against these *gross* benefits we have to charge the costs of mitigation (e.g., costs of new varieties) to determine *net* benefits.
Measurement challenges

• Current costs of pest or disease
  – Nature and extent (typical year? range?)
  – Across industry segments, agroecologies, etc.

• Vineyard-level effectiveness of innovation, if adopted
  – Damage mitigation
  – Net cost savings, price premia, etc.

• Odds of successful R&D

• Expected adoption patterns

• Timing (research, development, adoption)

• Other factors (environmental impact of reduced pesticide use and value of that impact)
Introduction to Pierce’s Disease

• **Pierce’s Disease**
  – Kills grapevines quickly
  – No known cure or available preventive measure
  – Spread by sharpshooters

• **Pierce’s Disease Control Program—since 2000**
  – Approximately $50 million annual budget
  – Prevention and research
  – Under threat from budget problems

• **PD research ~ $51 million (2000–2012)**
Our work

• Model the market for California wine grapes

• Simulate outcomes under alternative scenarios:
  – Prevalence of Pierce’s Disease
  – Policies for its management
  – Varietal innovations
Regional supply and demand model

• Six regions, linked through demand

• Inherently multi-period problem solved today
  – Age structure
    • Long time horizon
  – Parameterized linear form
    • Many uncertain parameters
  – Rational expectations
    • Economic and technological coherence matters

• Designed for comparing alternative policy scenarios
  – Not designed for forecasting
  – Comparing long-run average outcomes (not particular years)
Dynamic aspects

• Innovation takes time
  – R&D lags (often 10-20 years or longer, regulatory lags, too)
  – Adoption lags (especially when innovations embodied in genetics)
  – Impacts endure (until innovation becomes ineffective or obsolete)

• Perennial crops take time
  – Long lags in supply response to changes in price (or other factors)
  – Effects of investment responses felt over many years
  – Challenging to model unobservable expectations

• Pest and disease dynamics
  – Pest and disease population dynamics
  – Spatial spread of pest and disease
  – Not enough known about biology!
Spatial aspects

• Production of wine grapes varies spatially
  – Pest and disease prevalence
  – Production systems used
  – Yield and “quality” (price) of grapes

• Policy is specific to particular locations
  – Temecula
  – Southern San Joaquin
  – Napa-Sonoma

• Spaces linked through
  – (Potential) spatial movement of vectors
  – Product markets (different “qualities” substitute somewhat)
Supply-side regional aggregation

- Napa-Sonoma
- S. California
- S. SJV
- N. SJV
- N. California
- Coastal
Supply-side regional aggregation

<table>
<thead>
<tr>
<th>Region</th>
<th>Yield (tons/acre)</th>
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<tbody>
<tr>
<td>Napa-Sonoma</td>
<td>3.43</td>
</tr>
<tr>
<td>Southern California</td>
<td>5.71</td>
</tr>
<tr>
<td>Southern San Joaquin Valley</td>
<td>14.59</td>
</tr>
<tr>
<td>Northern San Joaquin Valley</td>
<td>8.88</td>
</tr>
<tr>
<td>Northern California</td>
<td>4.74</td>
</tr>
<tr>
<td>Coastal</td>
<td>6.41</td>
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</tbody>
</table>
Supply-side regional aggregation

- Napa-Sonoma
- S. California
- S. SJV
- N. SJV
- N. California
- Coastal

Map of California with regions indicated.
Supply-side regional aggregation

Napa-Sonoma
S. California
N. SJV
N. California
S. SJV
Coastal

http://www.flickr.com/photos/8463947@N08/996521785*
Supply model

• Producer “solves ” a 25+ year optimization problem in a forward-looking fashion

• Different rates of vine death and mitigation costs under alternative scenarios for
  – pest and disease prevalence
  – policy
  – technology
  => Parameterize scenarios based on advice from industry “experts”

• Model time path of acreage, production, and prices and compare scenarios (e.g., with and without new varieties)

• Validate in consultation with “experts”
Demand-side regional aggregation

- High-Price
- Medium-Price
- Low-Price
Supply and demand
# Summary of questionnaire results

## Estimated Losses with and without Program

**(Vines/1,000/year)**

<table>
<thead>
<tr>
<th>Region</th>
<th>With Current Policies and Technology</th>
<th>Without Current Policies</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
<td>Best-Guess</td>
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<tr>
<td>Napa-Sonoma</td>
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<td>Coastal</td>
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<tr>
<td>Northern San Joaquin Valley</td>
<td>0 – 2</td>
<td>1</td>
</tr>
<tr>
<td>Southern San Joaquin Valley</td>
<td>0 – 8</td>
<td>2</td>
</tr>
<tr>
<td>Southern California</td>
<td>2 – 10</td>
<td>4</td>
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<tr>
<td>Northern California</td>
<td>0*</td>
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</table>
Elicited parameters for PD resistant varietal R&D and adoption

<table>
<thead>
<tr>
<th></th>
<th>Conventional Breeding Parameters</th>
<th>Transgenic Parameters</th>
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<tr>
<td></td>
<td>High</td>
<td>Best Guess</td>
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<tr>
<td>Total R&amp;D (Years)</td>
<td>20</td>
<td>10</td>
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<tr>
<td>Adoption Rate (%)</td>
<td>100</td>
<td>80</td>
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<tr>
<td>Efficacy (%)</td>
<td>100</td>
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</table>
Average annual benefits from PD-resistant varieties – 20 year lag, 80% adoption

<table>
<thead>
<tr>
<th></th>
<th>Producer Benefits</th>
<th>Consumer Benefits</th>
<th>Total Benefits</th>
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<tbody>
<tr>
<td></td>
<td>$ thousand/year (2011–2060)</td>
<td></td>
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</tr>
<tr>
<td>Napa-Sonoma</td>
<td>9,498</td>
<td>5,820</td>
<td>15,318</td>
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<tr>
<td>Coastal</td>
<td>187</td>
<td>281</td>
<td>468</td>
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<tr>
<td>Northern SJV</td>
<td>213</td>
<td>1,170</td>
<td>1,383</td>
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<tr>
<td>N. California</td>
<td>–129</td>
<td>139</td>
<td>11</td>
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<tr>
<td>S. California</td>
<td>4,531</td>
<td>222</td>
<td>4,753</td>
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<tr>
<td>Southern SJV</td>
<td>11,471</td>
<td>2,877</td>
<td>14,348</td>
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<tr>
<td>Status Quo Prevalence State Total (20, 80)</td>
<td>25,772</td>
<td>10,509</td>
<td>36,281</td>
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Average annual discounted benefits from adoption, 50 year horizon

<table>
<thead>
<tr>
<th>% Adoption</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
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<tbody>
<tr>
<td>R&amp;D Lag (Years)</td>
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<tr>
<td>100</td>
<td>15.5</td>
<td>10.6</td>
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<tr>
<td>80</td>
<td>12.3</td>
<td>8.5</td>
<td>4.0</td>
<td>1.2</td>
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<td>60</td>
<td>9.2</td>
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<td>40</td>
<td>6.1</td>
<td>4.2</td>
<td>2.0</td>
<td>0.6</td>
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### Total present value of net benefits from adoption, 50 year horizon

<table>
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<th>% Adoption</th>
<th>R&amp;D Lag (Years)</th>
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<tr>
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Relative to Baseline, “Status Quo” Policy Scenario
Total present value of net benefits from adoption, 50 year horizon

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Thank You!
kbf Fuller@ucdavis.edu
jmalston@ucdavis.edu